Development of Materials for Fused Deposition Modeling

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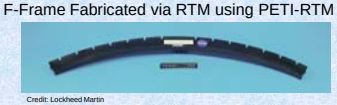
Polymers for Aerospace Structures

- Expertise in synthesis of structural engineering materials
  - Polyimides
  - Poly(arylene ether)s
- Resins to resist combined exposure to:
  - HighTemperature
  - Oxidizing Atmosphere
  - Mechanical Strain
  - Solvents, moisture, aircraft fluids
  - UV Radiation

Example Composites from High Speed Research Program

F-Frame Fabricated via RTM using PETI-RTM



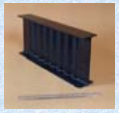
Credit: Lockheed Martin

PETI-5/IM7 Skin Stringer Panel (1.83 m x 3.05 m)

Credit: Boeing St. Louis

Parts Made From PETI-RFI via RFI

I-Beam



Credit: Boeing Long Beach

Sine Wave Spar

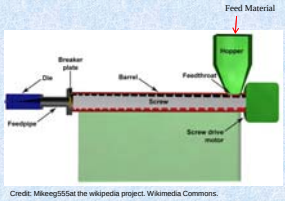
Credit: Boeing Long Beach

2 Bay Stiffened Panel

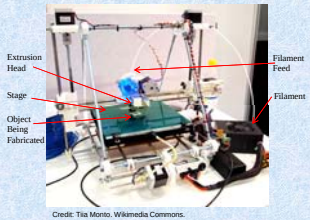
Credit: Boeing Long Beach

Engineering thermoplastics (i.e. Ultem™, PEEK, PC)

- Injection molding
  - Polymer melted with high shear
  - Mold pressures typically range 70 – 200 MPa
  - As injected part cools, material is held under pressure
- FDM
  - Melted in extrusion head
  - Semi-molten deposition
  - No consolidation pressure -> high void content



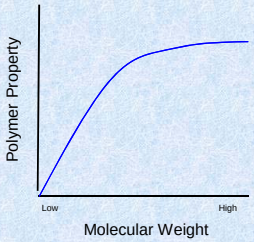
Credit: Mikeeg555at the wikipedia project. Wikimedia Commons.

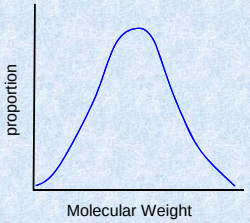


Credit: Tiia Monto. Wikimedia Commons.

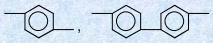
Effect of Polymer Molecular Weight

- Mechanical properties level out with increasing molecular weight
- Balance molecular weight, processabilty, and other properties through synthesis





Representative Group Effects on Polymer Properties



Increases Tg and melt viscosity, contributes to crystallinity, decreases solubility

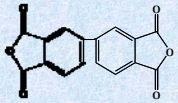
Increases Tg, provides atomic oxygen and fire resistance

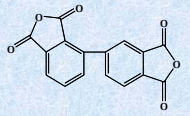
Improves solubility, leads to reduced color, lowers dielectric constant

Bulky pendant groups (CH_3, phenyl)

Increases Tg, improves solubility, lowers melt viscosity

- Liquid crystalline units for reduced melt viscosities
- Asymmetric (i.e. linear vs. kinked) monomer





- Incorporation of kinked units in polyimides has been shown to impart low melt viscosities while the polymers retain good mechanical and physical properties

Revector in-house capabilities

- Apply knowledge to development of new FDM materials
- Design materials specifically to leverage advantages of net shape fabrication
- Focus on properties required for structural aerospace applications